

WHAT IS CLAIMED IS:

1. A method of starting an internal combustion engine comprising:
setting a target kinetic energy as being a kinetic energy required for
starting the internal combustion engine; and
5 supplying a starting energy controlled in accordance with the target
kinetic energy to the internal combustion engine from a predetermined starting energy
supply source.
2. The method according to claim 1, wherein the starting energy supply
source includes a primary energy supply source and a secondary energy supply
10 source, a difference between the target kinetic energy and a kinetic energy supplied
from the primary energy supply source is obtained, and a kinetic energy
corresponding to the obtained difference is further supplied from the secondary
energy supply source.
3. The method according to claim 2, wherein the primary energy supply
15 source supplies the kinetic energy generated by a combustion within a cylinder of the
internal combustion engine.
4. The method according to claim 3, wherein a combustion energy
generated by the combustion within the cylinder is obtained based on a physical value
representing a state of an air/fuel mixture within the cylinder of the internal
20 combustion engine, and the kinetic energy to be supplied from the primary energy
supply source is estimated based on the obtained combustion energy.
5. The method according to claim 4, wherein the kinetic energy to be
supplied from the primary energy supply source is estimated by subtracting an energy
consumed by a mechanical loss owing to an operation of the internal combustion
25 engine from the combustion energy.
6. The method according to claim 3, wherein a cylinder in an expansion
stroke is identified when the internal combustion engine is stopped based on a state of
the internal combustion engine that is stopped, and the combustion is started within
each cylinder of the internal combustion engine one after another from the identified
30 cylinder.
7. The method according to claim 4, wherein a cylinder in an expansion
stroke is identified when the internal combustion engine is stopped based on a state of
the stopped internal combustion engine, a fuel is injected into the identified cylinder
during a period when the internal combustion engine is stopped, and a value of the

obtained combustion energy is changed in consideration with a diffusion state of the air/fuel mixture from the injection of the fuel to a start of the combustion within the identified cylinder.

5 8. The method according to claim 2, wherein the secondary energy supply source comprises an electric motor.

9. A system of starting an internal combustion engine comprising:
a starting energy supply source that supplies a kinetic energy required for starting the internal combustion engine; and
a controller that controls the kinetic energy to be supplied to the
10 internal combustion engine from the starting energy supply source in accordance with a predetermined target kinetic energy required for starting the internal combustion engine.

10. The system according to claim 9, wherein the starting energy supply source comprises a primary energy supply source and a secondary energy supply
15 source, and the controller controls a kinetic energy to be supplied from the secondary energy supply source in accordance with a difference between the target kinetic energy and a kinetic energy supplied from the primary energy supply source.

11. The system according to claim 10, wherein the primary energy supply source supplies the kinetic energy by causing a combustion within the cylinder of the
20 internal combustion engine.

12. The system according to claim 11, wherein the controller obtains a combustion energy generated by the combustion, which is supplied from the primary energy supply source based on the physical value representing a state of an air/fuel mixture within the cylinder of the internal combustion engine, and estimates the
25 kinetic energy to be supplied from the primary energy supply source based on the obtained combustion energy.

13. The system according to claim 12, wherein the controller estimates the kinetic energy to be supplied from the primary energy source by subtracting an energy consumed by a mechanical loss owing to an operation of the internal combustion
30 engine from the combustion energy.

14. The system according to claim 11, wherein a cylinder in the expansion stroke is identified when the internal combustion engine is stopped based on a state of the internal combustion engine such that the combustion within each cylinder is caused one after another from the identified cylinder by the primary energy supply

source.

15. The system according to claim 12, wherein a cylinder in the expansion stroke is identified when the internal combustion engine is stopped based on a state of the stopped internal combustion engine, a fuel is injected into the identified cylinder
5 in the expansion stroke, and the obtained value of the combustion energy is changed in consideration with the diffusion state of the air/fuel mixture from the fuel injection to a start of the combustion within the identified cylinder.

16. The system according to claim 10, wherein the secondary energy supply source comprises an electric motor.

10 17. A method of starting an internal combustion engine comprising:
injecting a fuel into a cylinder in an expansion stroke when the internal combustion engine is stopped such that the fuel is combusted within the cylinder to generate a combustion energy for starting the internal combustion engine;
obtaining the combustion energy generated by combusting the fuel
15 based on a state of an air/fuel mixture within the cylinder to which the fuel is injected;
estimating a kinetic energy generated by the combustion and supplied to the internal combustion engine based on the obtained combustion energy; and
supplying an energy from a predetermined starting energy supply source, the energy corresponding to a difference between a predetermined target
20 kinetic energy required for starting the internal combustion engine after starting the combustion and the estimated kinetic energy.

18. A system of starting an internal combustion engine for injecting a fuel into a cylinder in an expansion stroke when the internal combustion engine is stopped using a combustion energy generated by combusting the fuel, the system comprising a
25 controller that:

stores a target kinetic energy set as a kinetic energy required for starting the internal combustion engine;
obtains the combustion energy generated by combusting the fuel based on a state of an air/fuel mixture within the cylinder to which the fuel is injected;
30 estimates a kinetic energy generated by the combustion and supplied to the internal combustion engine based on the obtained combustion energy; and
serves to supply an energy from a predetermined energy supply source, the energy corresponding to a difference between the stored target kinetic energy and the estimated kinetic energy.

19. A method of estimating an energy for starting an internal combustion engine in which a fuel is injected into a cylinder in an expansion stroke when the internal combustion engine is stopped, using a combustion energy generated by combusting the injected fuel, the method comprising:

- 5 obtaining the combustion energy based on a physical value indicating a state of an air/fuel mixture in the cylinder of the internal combustion engine;
- estimating a kinetic energy generated by the combustion based on the obtained combustion energy; and
- determining a kinetic energy by obtaining a difference between a
- 10 predetermined target kinetic energy required for starting the internal combustion engine and the estimated kinetic energy so as to be supplied from an energy supply source other than the combustion of the injected fuel within the cylinder to the internal combustion engine.

20. A system of estimating an energy for starting an internal combustion engine in which a fuel is injected into a cylinder in an expansion stroke when the internal combustion engine is stopped, using a combustion energy generated by combusting the injected fuel; the system comprising a controller that:

- 15 stores a target kinetic energy to be set as a kinetic energy required for starting the internal combustion engine;
- 20 obtains the combustion energy generated by combusting the fuel based on a physical value indicating a state of an air/fuel mixture in the cylinder of the internal combustion engine;
- estimates a kinetic energy generated by the combustion based on the obtained combustion energy; and
- 25 determines a kinetic energy by obtaining a difference between the stored target kinetic energy and the estimated kinetic energy so as to be supplied from an energy supply source other than the combustion of the injected fuel within the cylinder to the internal combustion engine.